Canadian
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Report No. 10
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A NEW APPROACH TO PEST CONTROL IN CANADA

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PREFACE

Every jurisdiction in Canada ranks toxic chemicals among its greatest environmental concerns. Such chemicals are usually thought of as wastes whose escape into the environment is accidental, a consequence of the modern industrial society in which we live. However, one class of toxic chemicals is not a waste, vagrant in the environment because it eluded some industrial process or resulted from a spill. This class of chemicals is very consciously and deliberately released into the environment to serve a very specific purpose: pest control.

Chemical pesticides are poisons by their very nature, else they would not serve their only function of killing organisms whose actions run counter to our perceived best interests. For many years, concern over pesticides focussed on the immediate health hazards to those in areas where they were used, and on people eating food contaminated by pesticide residues. It is only in the last two decades that our concern has expanded to include long term effects on human health of exposure to trace amounts of pesticides and to their general environmental impacts. The dogma that if pesticides are used following the directions on the container there will be no risk, is no longer tenable. The early organic, artificially synthesized pesticides were probably rarely used improperly in this narrow sense, and yet research in many parts of the world demonstrated their devastating, long term effects on ecosystems. Many have now been banned for use.

In 1978, as a reflection of this concern, the Canadian Environmental Advisory Council undertook to prepare a report for the Minister of Environment on the use of pesticides in Canada from an environmental perspective. It put this study in the capable hands of Dr. Ross Hall, who has been a member of Council since 1975.

Dr. Hall's study went through many stages of evolution. Gradually he concentrated his attention on two basic aspects of the issue: the regulation of pesticides at the federal level; and the appropriateness of using toxic chemicals for the suppression of pests in the first place. His report has been discussed by Council at many meetings and it has gone through many revisions. With the patience of Job, Dr. Hall survived these tests with flying colours, and his report was approved unanimously by Council at its meeting on July 8, 1981.

Donald A. Chant
Chairman

Acknowledgement

The writing of this report has been facilitated by consultation with officials of the federal Departments of Agriculture, Environment, Fisheries & Oceans, and National Health & Welfare, as well as other institutions. Their generous provision of background information and frank comments on the ideas presented in this report have been invaluable. Selection of material and commentary in this report, however, remain the responsibility of the author and the Canadian Environmental Advisory Council.

Although the report is authored by a single member of the Council, it is the result of intense and thoughtful discussion among all members of the issues and policies. The author wishes to thank, in particular, the Chairman, Dr. D.A. Chant, for his strong support of this undertaking and for his highly professional input into the preparation of the report.

NOTE: The word *pest* includes insects, weeds, bacteria, fungi, rodents, etc., that either attack or compete with a production crop or domestic animals.

The word *pesticides*, unless specifically defined, refers to chemicals, almost all synthetic.

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ABSTRACT

Pesticide application has become an integral part of agriculture and forestry technique. Its use in Canada has risen dramatically since 1940 and herbicides account for 50 percent of the pesticides used, but exclusive reliance on chemicals is facing serious problems. The number of resistant pests is increasing and the number of new pesticides introduced on the market has declined.

Pesticides are deliberate environmental poisons with profound effects on organisms other than the target, yet we lack a fundamental understanding of environmental impact. Few registered in Canada have been subjected to the full gamut of known environmental tests.

With no Canadian pesticide industry, no pesticides are developed specifically for domestic pests. Supporting information for registration is furnished by the manufacturer. Test protocols have been developed for and testing carried out in other countries. Canada has no control over the testing facilities of or access to information accumulated by the industry.

Environment Canada examines only cursorily the environmental effects of registered pesticides, has no systematic monitoring program and is not privy to all pesticide information in the files of Agriculture Canada.

Alternative, non-environmentally damaging control strategies such as biological control, changes in cultural practices or introduction of specific pathogens shift the emphasis from exclusive reliance on chemicals. Integrative Pest Management (IPM) attempts to reduce pest damage using a more sophisticated, multi-technique approach. Successful implementation of IPM and biological techniques on a large scale can be achieved only if producers are assured that no economic dislocation will result. The proper economic and political decisions would permit Canada, with its substantial body of expertise, to minimize the use of chemicals in favour of control techniques designed in Canada for Canadian conditions.

This report suggests four options: i) to do nothing risks continuing environmental damage; ii) to tighten up Environment Canada's role under the Pest Control Products Act would force more rigorous imposition of environmental criteria; iii) to transfer administration of the Act to Environment Canada would help to ensure that environmental rights are more effectively represented; iv) to create a Commission, jointly administered by the Departments of Environment, Agriculture and National Health & Welfare, empowered to examine pest control problems in their totality. It would focus the regulatory mechanism on the problem itself and *all* the alternatives for its resolution, and to have the power to regulate control strategies. The Canadian Environmental Advisory Council recommends this option.

I. INTRODUCTION

For every pound of human being, according to one estimate, there are twelve pounds of insects. Although most insect species are not pests, those that are clash directly with humans, competing for food and fibre. Crops themselves must compete with a host of sturdy versatile weeds that sap strength and reduce yields. This fierce competition, in spite of modern control methods, has never stabilized, for, as conditions change, food and fibre producers must constantly struggle to maintain a human advantage. Control strategies for the past 30-40 years have been based mainly on the use of chemical poisons, pesticides. For reasons of pest resistance, increasingly high economic costs and public concern over the toxic effects of pesticides, control strategies are moving away from exclusive reliance on pesticides.

This report deals with the federal role in pest control, in particular the role of Environment Canada.

1. *Pesticides Registration*

Pesticides by their very nature are environmental poisons. Recognizing this fact, the federal government, through the Pesticide Control Products Act administered by the Minister of Agriculture, requires that all pesticides be evaluated for safety. Chemicals deemed safe under specific conditions of use are granted registration. A body of officials in the Department of Agriculture, assisted by human safety experts in the Department of Health & Welfare, together with *ad hoc* input from other interested departments, constitutes the actual evaluation authority.

The existing registration process is rapidly becoming outdated. One reason is that the perception of "safe" has undergone considerable change over the past two decades. It is now realized that many pesticides previously deemed to be safe have long term toxic effects, and most importantly, that it is extremely difficult to assess these effects in advance of using these materials under field conditions.

This lack of knowledge has been compounded by the passive role that Environment Canada has played in the pesticide registration process. Some pesticides, almost by chance, have received extensive environmental impact assessment, but most now being applied in the Canadian environment have received practically no assessment at all.

If Environment Canada were to apply rigorous criteria to the assessment of the environmental toxicity of pesticides, few if any of the 405 currently registered ones would be likely to pass. In addition, it is unlikely that any new chemical pesticide would be registered.

2. *Limit of Pesticide Technology*

The modern era of pesticide technology began about 40 years ago. The most effective pesticides (for example, the insecticide DDT and the herbicide 2,4-D) were discovered at the beginning of this epoch. Several million compounds have been screened over the last four decades as potential pesticides. A few as good, some with more desirable ancillary properties, but none better in their primary purpose, have been discovered. It is a mistake to believe that there are magic chemicals awaiting discovery that will effectively control pests and, at the same time, meet the more realistic modern criteria of "safe".

3. *Alternative Strategies*

Canada is fortunate in having a cadre of experts and a body of experience in alternative strategies. These strategies include biological control and Integrated Pest Management (IPM). Such strategies may include use of chemical pesticides, but they tend to minimize or phase out chemical use.

Although many examples of alternative strategies have been put into practice, in general implementation is slow and subject to severe economic constraints. This report argues that the present expertise should serve as a base for implementing a new, nation-wide strategy of crop resource protection that would markedly reduce and eventually eliminate the environmental impact of chemical pesticides.

4. *Evaluation of Control Strategies*

Evaluation of comprehensive strategies requires a different mechanism than the present pesticide registration procedure. *This report recommends replacement of pesticide registration with a pest control commission operating with its own statutory authority.* It would relate closely to the three most relevant federal departments, Agriculture, Environment, and Health & Welfare.

Such a Commission would evaluate control strategies proposed for a single pest, or the problems of crops, or a locality or region. It would consider all the alternatives, and marshall necessary resources so that the course of action it chooses can be implemented.

The Commission would also, in consultation with the operating divisions of agriculture and forestry, initiate research and developmental programs leading to new strategies. Responsibility for research, development and implementation would remain in the operating divisions.

The success of this Commission would depend on strong input from Environment Canada, through its responsibilities for forestry and environmental protection. Environment Canada would need to reorder its priorities to meet this challenge.

The concept of resource management implicit in these recommendations goes beyond production of wheat, onions and timber. It encompasses the total environment as a living resource. It recognizes that the living environment is a very complex, hard-to-understand system. It underscores the fact that humans are but one of millions of species necessary to make an environment work. Our own vitality depends on a holistic concept of the environment.

II. PESTICIDE TECHNOLOGY

A major technology that has enabled agriculture to intensify its practice is the widespread application of chemical pesticides, substances that kill insects, weeds, fungi and other competing organisms. Pest control has a long history. Roman farmers, for example, used oil of leeks, camel urine and companion planting to control pests. In the first part of this century, farmers used large amounts of natural poisons containing lead, arsenic, copper and sulphur. None of these substances was very effective and farmers, through cultural practices, developed a number of strategies to cope with their pests. Prairie farmers fallowed their land every second or third season, not only to conserve moisture but, just as importantly, to control annual weeds.[1] Farmers in other parts of Canada mixed and rotated their crops, timing their planting and harvesting schedules to avoid periods of potentially heavy infestations.

This was the state of Canadian agriculture in 1940, at which time only about 30 pesticides were registered for use (McEwen & Stephenson, 1979). This situation changed abruptly in the 1940's with the introduction of DDT and other synthetic, man-made pesticides. To agriculturalists of the 40's and 50's, DDT seemed miraculous, killing every insect it touched, without any apparent toxicity to humans and wildlife. DDT's discovery sparked the beginning of a world wide revolution which produced some 1,500 different chemical poisons that kill insects, weeds and other organisms competing for man's food and fibre. In Canada, 405 of these chemicals are now registered for use as pesticides. Each active ingredient, however, can appear in an unlimited number of formulations, at last count some 3,000.

Advent of the synthetic pesticides has encouraged a restructuring of agricultural practice. Pesticide application has become an integral part of agricultural technique. Consequently, yields and quality of most crops now grown in Canada could not be sustained if pesticide use were suddenly withdrawn, accompanied by no other changes in agricultural practices.

From the point of view of manufacturers and vendors of pesticides, pesticide technology has become enormously successful. In Canada, total sales now exceed $200 million per year. Sales and

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[1]Nevertheless, summer fallowing is partly responsible for excessive loss of organic material and in some areas loss of productivity due to accumulation of salts (Rennie & Ellis, 1978).

amounts of pesticides applied to Canadian agricultural land continue to mount each year (Figure 1). With this economic success, however, problems for the user and for the public at large appear to be multiplying rapidly.

Pesticide technology deals with life. It pits the ingenuity of pesticide designers against the resiliency and wiles of nature.

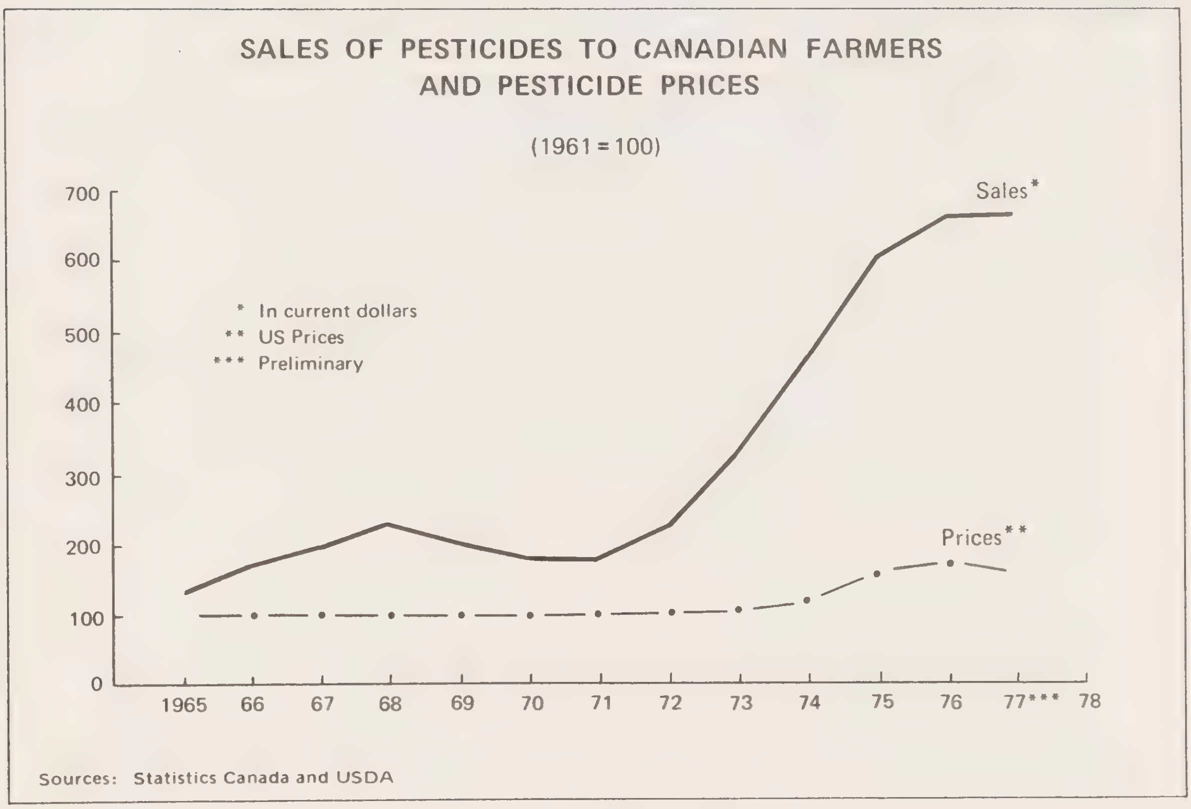

Figure 1

Is Pesticide Technology Failing?

The continuing success of pesticide technology, even when measured by the limited criteria of marketable yield, may have reached a plateau and as a long-term strategy has begun to fail. The Director of the United Nations Environmental Program (UNEP), in his 1979 State of the World Environment Report, cited the rising number of insect pests now resistant to insecticides: 182 species in 1965, 278 species in 1968 and 304 species in 1977 (Tolba, 1979). Particularly worrisome are reports of resistant disease pathogens. In the period 1965-1970, there were few reports of plant diseases resistant to fungicides, but 35 resistant species have now been identified. Seven species of rats, a major cause of crop loss before and after harvest, are now resistant to rodenticides.

Pre-1940 pesticides did not promote resistance as readily as, paradoxically, do the strong modern ones. The reason lies in biological diversity. Insects, weeds, and fungi exist as billions of individuals. The highly effective pesticide initially kills close to 100 percent when first introduced. The few resistant survivors, with their susceptible brethren killed, begin to multiply rapidly and sooner or later the resistant form dominates.[2]

Forty years of intense research (starting with DDT in 1940) has failed to create pesticides that are selective against target vs non-target organism and that are without environmental hazards. This defect in design becomes more apparent as the level of biological understanding of the effects of pesticides increases. DDT, for example, when first introduced, was thought to be absolutely selective against insects with no effect on warm-blooded animals. This turned out to be untrue; DDT indeed causes severe neurotoxicity in many warm-blooded animals.

As sophistication in biological understanding has increased over the years, criteria for pesticide registration have been made increasingly more stringent. One consequence has been a sharp decline in the number of new pesticide chemicals registered. In the United States the number dropped from 28 in 1965 to eight in 1975 (Goring, 1977). In Canada, registration of new active ingredients which for several years averaged 10 a year, dropped to four in 1979 and four in 1980 (Pest Control Division, Agriculture Canada). In other words, the more that is learned about the harmful environmental effects of pesticides the harder it is to design a pesticide that is economically effective and still satisfies environmental criteria.

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[2]In spite of the generous applications of strong pesticides since 1940, the belief of agriculturalists of that era that insect pests could be eradicated has not been realized. Not a single pest has been eliminated. More realistic understanding of the power of nature in the past decade has made alternative controls look more attractive.

Trying to Understand Environmental Effects of Pesticides

Although the environmental effects of some pesticides are now well-known, it should not be inferred that understanding of environmental effects of all pesticides is substantial. An increase in understanding has indeed occurred, but it started from an almost zero data base at the time the first synthetic pesticides were marketed. Knowledge of environmental effects in 1981 remains limited for two reasons:

1) *Lack of fundamental understanding.* Environmental effects of pesticides are a hodge-podge of observations. It is uncertain which effects are significant and which are not. There is no underlying theory that can integrate the diversely observed environmental effects.

2) *Tests that could be done and are not.* Few of the currently registered pesticides have been subjected in any country to the full gamut of known environmental tests that could be performed.

Should we be concerned about so much ignorance? The dilemma can be illustrated with the giving of a drug to a human patient. The drug has a potential for side effects. If these occur, they are observed, their severity measured and the over-all condition of the patient accurately assessed. The physician can rectify the situation by withdrawing the drug and providing appropriate countermeasures. If the physician, for whatever reason, ignores the side effects, they may easily reach a point of irreversible damage.

Pesticides are the equivalent of environmental drugs applied to deliberately change an aspect of ecology. In contrast to the human patient, we have few well-defined criteria that allow us to determine side effects and to alert us to any overall deterioration of the environment's condition. Yet we know pesticides are poisons that can harm organisms other than the targeted ones. It is only prudent to assume that such harm indicates environmental damage and that at the present level of knowledge we must judge all evidence of harm as significant.

The irony of this situation is that for most of the 405 pesticides registered in Canada, environmental effects under Canadian conditions have not been and are not being assessed. Patients can sue their physicians for malpractice if they ignore the side effects of an administered drug. What recourse have Canadians or the Canadian environment?

Known Environmental Effects of Pesticides

The effects of pesticides that we term environmental effects are toxic manifestations of a single pesticide on a specific organism. They fall into two categories. The simplest and most frequently observed effect is death of member species. Birds such as robins, sparrows, warblers, flickers, and chickadees suffered severely in the 1950's in communities which tried to control Dutch Elm disease with DDT (Wallace 1959; Hunt, 1960).

Environmental toxicity can occur in much more subtle ways. Fish behaviour, for example, can be modified by trace quantities of pesticides or their breakdown products. DDT exposure causes some species of fish to lose their migratory instinct (Dill & Saunders, 1974). Crabs, on exposure to chemical surfactants used as pesticide vehicles, confusedly try to mate with rocks. Reproductive processes of fish and other wildlife can be upset. Young are hatched or born deformed.[3] One of the more troubling aspects is that the effects often do not manifest themselves until a later generation.

The reproductive biology of wildlife is particularly sensitive to the harmful effects of chemicals. Humans are not exempt. One pesticide, dichlorobromopropane, was banned after male workers in the plants that manufactured it became sterile (Stevens, 1977). This effect came to light only after the workers, otherwise perfectly healthy, noticed that, as a group of relatively young men, they were not fathering children.

These observations were made on specific pesticides that happened to have been studied. It does not suggest that all pesticides cause similar effects, but it does point up that most observations have been made on a haphazard or *ad hoc* basis. Significantly, these observations were made after the pesticide was registered and in commercial use.

The political principle has been and remains: only concrete evidence of harm will suffice to withdraw a pesticide once it has been registered. The difficulty of obtaining evidence of what is defined as harm is compounded by the lack of trained scientists to study these problems.

This can be illustrated by one area of importance to all life - soil ecology. There are only three scientists in all of Canada[4] engaged in the full time study of soil fauna. The situation is no better in the United States where the proportion of such scientists is similar.

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[3] An extensive review of the effects of pesticides on wildlife can be found in McEwen & Stephenson (1979).

[4] One in Agriculture Canada, one in the Canadian Forestry Service, and one in a university.

A committee of the United States Department of Agriculture (USDA) acknowledged that most pesticides destroy or suppress soil life. The committee,moreover, commented that although specific fragments of information were available, the overall significance of the chemical interference in soil life remains unknown (USDA Study Team, 1980).

Soil conditions are local, and if there is to be any understanding of environmental effects in the soils of Canada, studies must be conducted in Canada. If this were to become government policy, it is obvious that it could not be implemented until more scientists are trained.

The Not-So-Magic Bullet

In short, we remain profoundly ignorant of the environmental effects of pesticides, although sufficient evidence has been amassed to know that harm is being done. We might ask why a major agricultural technology - pesticides - has been put in place without, at the same time, establishing the means to monitor its harmful side effects. The answer lies partly in the myth of the magic bullet.

The myth originated with Paul Ehrlich (1854-1915), a medical pioneer in the use of drugs. He was convinced that chemicals could be found that, like a magic bullet, would selectively alter one desired biological process and touch no other. DDT seemed to be one of those magic bullets. We know now that such thinking is naive. Magic bullets do not exist. Any chemical that has one observable biological effect inevitably will have many others though they may not be noticed immediately. Chemicals that have the power to disrupt the biological processes of weeds, insects, fungi, etc. have the power to disrupt the well-being of many other organisms.

Pesticide Use in Canada

The total use of pesticides has risen steadily since 1940 with a dramatic increase in the last 20 years. The volume of pesticides has shot up five-fold (Table I). One reason for the sharp increase is the use of herbicides, which now accounts for more than one half of all pesticides applied in Canadian agriculture. On the Canadian prairies, for example, 80 percent of crop land is sprayed with 2,4-D (2,4-dichlorophenoxyacetic acid) or its close relatives. In addition, 40 percent of crop land is sprayed specifically with killers of wild oats, which are unharmed by 2,4-D (Hay, 1980). The total weight of pesticides applied to Saskatchewan each year amounts to four kilograms per capita, the highest in Canada.

TABLE I

SALES OF PEST CONTROL PRODUCTS BY CANADIAN REGISTRANTS, 1977*

	Quantity		Value
	1000 lbs.	1000 kg.	$10 K
Agricultural Insecticides	18,180	8,250	18,130
Agricultural Fungicides	5,130	3,200	10,080
Seed Treatment	160	70	7,020
Growth Regulants	660	380	5,240
Agricultural Herbicides**	36,270	19,420	125,160
Agricultural Rodenticides	1,140	520	740
Home & Garden Products	4,460	2,280	33,550
	6,375,577 units		11,180
Industrial Insecticides	400	180	470
	127,059 units		20,830

**Continuous cropping of grain presents special problems of weed infestation. From the time of nineteenth century sod-breaking until the 1950's, farmers tried every conceivable combination of tillage, delayed planting and harvesting techniques with only limited success. It is not surprising that they embrace the seemingly miraculous and easy-to-use chemical herbicides. Cultural methods fell into disuse.

As herbicides have taken over the role of previous cultural practices, many prairie farmers, according to one Agriculture Canada official, have become less and less interested in those practices. The rapidly increasing applications of herbicides and other pesticides in Canadian agriculture has built up substantial momentum and increasing application can be projected well into the 1980's.

*Statistics Canada

Canadian forests receive about one-fifteenth as much insecticide as does agricultural land (Table II). Whereas many agricultural pest problems recur regularly every season, most forestry problems wax and wane over longer periods of time. Thus, spraying of forests is generally confined to a region and time of a particularly serious infestation although, because of the large contiguous areas, the environmental impact can be severe. Pesticides used on forests are registered under the federal Pest Control Products Act (PCP Act) in the same way as agricultural pesticides.

TABLE II

PESTICIDES USED ON FORESTS, 1980*

Province	Agent	Area (acres)	Amount (lbs)
Newfoundland	*Bacillus thuringiensis*	34,835	-
Nova Scotia	*Bacillus thuringiensis*	70,260	-
New Brunswick	*Bacillus thuringiensis*	54,000	-
	Matacil	600,000	37,500
	Fenitrothion	3,400,000	637,500
Québec	*Bacillus thuringiensis*	49,286	-
	Matacil	65,593	4,100
	Fenitrothion	785,026	147,190
Ontario	*Bacillus thuringiensis*	10,000	-
	Matacil	15,000	940

*Spraying is a provincial responsibility. These data were supplied by the Canadian Forestry Service, based on information from the provincial services.

The substances listed in this table are insecticides. In addition, in 1980 the herbicides 2,4-D and 2,4,5-T either separately or in combination were sprayed on forests in Newfoundland (500 acres), New Brunswick (35,000 acres), Ontario (50,000 acres) and Alberta (1,000 acres).

It is quite possible that herbicide use will increase. In young forests, when hardwood growth is killed by the herbicides, the softwoods break through and establish themselves more quickly than if spraying were not done. The productivity of a forest thus treated can be doubled. If forest management becomes a trend, managers will be pressing for increased use of the herbicides, which raises environmental implications. It also offers an incentive to develop alternatives that do not require 2,4-D or 2,4,5-T.

Manufacture and Marketing of Pesticides in Canada

The technology and expertise for developing and making chemical pesticides reside exclusively with the chemical industry. It is a highly sophisticated business which is carried out by only the largest of chemical companies. The development of a new pesticide costs in the order of $25 million and because of these high development and promotion costs, chemical companies seek economic winners. E. Blair of Dow Chemical Company defined a winning pesticide as one with a market lasting nine years, an annual sales level of $20 million (1970 dollars) and a return on investment of 40 percent before taxes (*Pesticide economics....*, 1972). To ensure such economic gains, companies aim their new products at the big world markets of cotton, corn, rice and wheat.

In terms of world agriculture, the value of Canada's crops are insignificant. If any of the world-developed pesticides finds a use in Canada, so much the better for the manufacturer, but the Canadian market offers no special incentive. In terms of specific manufacturing knowledge, Canada possesses none and is totally incapable of developing any pesticide for its own specific use. We are dependent on Holland, Switzerland, Germany, France, Great Britain and the United States for developing and making pesticides, largely tailored to the needs of others.

The Canadian subsidiaries of international chemical companies sell most of their pesticide products directly to the users or distributors. They have in place extensive marketing systems employing a substantial number of sales people.

The fact that chemical pesticides are first developed for other crops in other countries poses the question of how they are selected for use in Canada. If a company believes that its new pesticide will find a use, it presses for Canadian registration. Scientists of Agriculture Canada and the Canadian Forestry Service sometimes play a major rôle in the selection. Research stations in these two services devote substantial budgets to testing candidate pesticides against specific pest problems under local growing conditions. They study efficacy, persistence and toxic effects on crops and, in the case of the Forestry Service, on certain wildlife species.

In some cases, because of their studies, a new pesticide has been registered in Canada before other countries. It should be noted parenthetically that the Minister of Agriculture permits experimental pesticides to be tested in the field without registration.

Chemical companies are in the business of making profits by selling chemicals. In a complex ecological relationship of human-pest-food and fibre, they quite understandably have organized knowledge to favour a chemical perspective. Such a perspective constricts a total view of life, akin to trying to chart the patterns of stars from the bottom of a well. Biological thinking has advanced considerably since 1940 when it seemed that the only knowledge necessary to deal with insects, for example, was how to apply DDT. In spite of this, a chemical perspective continues to dominate the technology and economics of pest control.

Pesticide Regulation in Canada

The chemical perspective is highly evident in government attitudes and allocation of resources. Substantial public monies go to support a chemical pesticide registration program that amounts to government validation of chemical products. In light of the now recognized limitation of chemical pesticides and the increasing awareness of their harmful side effects, the public can rightly ask whether a registration program conceived in the 1930's is satisfactory in the 1980's.

Primary responsibility for the regulation of pesticides rests with the federal government. A comprehensive regulatory act, the Pest Control Products Act was promulgated in 1939, with amendments in 1972. Administered by the federal Minister of Agriculture, the Act requires that pesticides which are imported, manufactured or offered for sale in Canada must be registered. In addition, the Act provides for the regulation of manufacturing premises, storage, distribution, display and labeling of pesticides.

Most provincial governments have enacted legislation to control sales outlets, vendors and users of pesticides; for example, the licensing of applicators. Where federal and provincial legislation applies to the same facet of pesticide control, the more restrictive always applies. In effect, the federal PCP Act provides a uniform level of control across Canada and provincial law can only be more specific or more stringent.

The spray calendars which provinces publish each growing season contain information arrived at through consultation between Agriculture Canada specialists working in each region, provincial and university specialists and representatives of the pesticide companies.

To register a pesticide under the federal PCP Act, a proponent company submits to the Department of Agriculture a dossier of completed tests with respect to the candidate chemical's efficacy

and its side effects. Agricultural officials may send those parts of the application they deem relevant for review to Departments of National Health & Welfare, National Defence, Fisheries & Oceans, and Environment. Officials of these departments may request through the Department of Agriculture additional information relevant to their concerns. They do not, however, examine the whole application or know all the information it contains. Regardless of any recommendation or conclusion other departments may make, final decisions are made solely by officials of Agriculture Canada.

There is one rider to that authority. If a candidate pesticide seems likely to leave a residue in food as eaten, the Health Protection Branch, Department of National Health & Welfare, has the authority to set legal tolerances that cannot be exceeded. This agency can condemn food shipments that exceed legal tolerances for pesticides.

The federal government itself is a major consumer of pesticides, for example, in parks, Crown Lands, and other government properties. A federal Interdepartmental Committee on Pesticides (FICP) made up of members from the above departments under the chairmanship of the Assistant Deputy Minister (Research) of Agriculture Canada ensures that usage of pesticides on government lands conforms to governmental regulations.

Another source of advice is provided by the Canadian Agricultural Services Coordinating Committee (CASCC), members of which include federal and provincial deputy ministers and the deans of faculties of agriculture. This committee has struck a number of subcommittees, such as the Expert Committee on Weeds. Most pesticides are used internationally and the Organization of Economic Cooperation and Development (OECD), of which Canada is a member, has taken responsibility for coordinating criteria used for pesticide regulations and keeping members informed about international developments and problems.

Source of Information on Which Registration is Based

It should be kept in mind that government departments have very limited testing facilities. Practically all information about a candidate pesticide is furnished by the applicant company, which has responsibility for doing the necessary experiments at its expense. Canada lacks both a domestic pesticide industry and toxicological facilities, and thus all candidate pesticides are developed and initially tested in other countries.[5] Canada has no control over, or access to,

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[5]UniRoyal maintains a laboratory in Guelph, Ontario, which develops new pesticides. This laboratory, however, is part of an international company developing pesticides for the world market, not the Canadian market.

the testing facilities used by the applicant companies, and in effect, cannot verify the data submitted to it.

The danger of this exclusion was highlighted by disclosure that one quarter of the pesticides now registered in Canada were granted registration on the basis of data that could be false. Thirty pesticide companies in the United States had contracted with Industrial Biotest Laboratories (IBT), in Illinois to do their toxicological testing. Four years ago the United States Environmental Protection Agency (EPA) and the Food & Drug Administration (FDA), on the basis of an audit, alleged that Industrial Biotest falsified some of the data for each of approximately 115 pesticides registered in Canada and the U.S. (EPA, *News Release*, 1977). This revelation left Ottawa authorities wondering how much of the data they had on file could be trusted (see Appendix I).

Although the IBT scandal is regrettable, this critique is more concerned with the efficacy of the registration process when it is working perfectly. That efficacy can be no better than the quality of information fed into the process which even when honestly obtained and evaluated remains limited, inadequate and often irrelevant to the toxicological problems facing the Canadian environment and public.

Review of Registered Pesticides

Once a pesticide is registered and the longer it is used, de-registration or withdrawal becomes increasingly difficult. The attempts to deal with the registered fungicide, Captan, illustrates this problem and at the same time reveals attitudes towards pesticides.

Following the IBT revelations, some 15 of the original 17 safety tests submitted to Agriculture Canada in the original application of Captan turned out to be false or suspected of being false. Moreover, since the original registration in 1951, experiments had shown that Captan causes cancer and birth defects in test animals.

On the agriculture side, Captan had proven its worth. It is used extensively as a seed dressing and is sprayed on fresh fruits and vegetables to prevent mold.

Officials of National Health & Welfare, based on concerns for human safety, recommended that Captan be withdrawn. Concluding that the adverse effect on the agricultural system of withdrawal would be too severe, the Minister of Agriculture, invoking his authority, declined to withdraw the fungicide. In making that

judgement, his officials must have assumed that the buying public preferred Captan residues in their produce to having the odd bit of mold. Public education should be a component of pesticide judgements, something not now done.

A ban on Captan, in the view of Agriculture Canada, would also complicate foreign trade. Imported fresh fruits and vegetables contain Captan residues, and a ban in Canada would tend to prevent importation of much of Canada's fresh produce. This episode shows that even though the case is compelling, it becomes very difficult to force withdrawal of a registered pesticide once it is in commerce.

Limits to Knowledge

The whole registration procedure is designed to ensure that the harmful effects on non-target organisms will be minimal vis-à-vis the intended target. Judgement as to how minimal the non-target effects should be is based on two categories of evidence.

First, what exposures will non-target species receive? How stable is the pesticide and how far is it transported by air, water and/or food before it breaks down? These questions fall under the category of *persistance*. Many of the earlier pesticides, such as DDT, persisted in the environment for years. Companies are now trying to design pesticides with short half-lives. Measurement of persistance is not always simple. In many cases, instrumentation is unable to detect levels of residues which have harmful biological effects. Moreover, the fact that the original pesticide vanishes does not mean that one or more of its breakdown products might not harmfully persist.

It must be emphasized that the objective of pesticide companies is to register their product in countries of maximum use, e.g., the United States, They develop data to satisfy regulatory agencies of those countries. Most of the data concerning persistence are obtained under soil and climate conditions pertaining to the United States or other big users. The data do not necessarily pertain to the variety of Canadian conditions, a situation that weakens the so-called "safety" base of Canadian registrants.

In the second category, the *toxicological effects* of pesticides on non-target species are assessed. This, perhaps, is the feeblest link in the registration process because judgements must be based on classic toxicological techniques. A previous report on ecotoxicity (Hall & Chant, 1979) outlined the weakness of science in determining degrees of toxicity. In particular, that report documented the great difficulties scientists have in determining the effects of chronic exposure to trace quantities of poisons.

It is precisely this aspect of toxicological testing of pesticides that is most relevant to environmental and human safety. Pesticides are registered in Canada and elsewhere with only minimal understanding of the long-term effects on the environment such as population shifts, or on humans such as birth defects, mutations, allergic reactions, cancer or heart disease. Awareness of this ignorance troubles some officials. The former Administrator of EPA said, "In the past we willingly accepted claims that pesticides have no long-term effects in humans. Neither EPA or industry is in a position to make such reassurances honestly" (Costle, 1980).

Costle's caution does not seem to be shared by the president of the Canadian Agricultural Chemicals Association, who stated, "every registered pesticide in Canada is safe as well as effective *when used according to label directions*" (St. Clair, 1980).

Safety, like beauty, is obviously a relative term. Safety to whom or to what? As brought out in this report, environmental testing is so inadequate that for most of the 405 registered pesticides, no exact judgement of environmental safety can be made. Safety, however, is generally thought of in human terms. Officials of the Department of National Health & Welfare can make fairly good judgements whether or not a pesticide will, in the near term, poison pesticide applicators, or eaters of food containing its residues. Because of the difficulty of testing, they often cannot make a satisfactory judgement about long term effects on human health.

National Health & Welfare, moreover, is handicapped by the lack of environmental testing and monitoring in Canada. It receives practically no information about movement of pesticides through the environmental food chain, or information about effects of pesticides breakdown products. This missing information is critical to making judgements about the *safety* of chemicals broadcast in the environment. Until the environmental impact is properly studied, there is no sure way of ruling that a pesticide is safe to humans.

It must also be emphasized that pesticide testing is done on each pesticide one at a time. No attempt is made to assess the effects on humans and other non-target organisms of multiple chemical exposure, the real life situation. The present testing system falls far short of validating the actual safety of chemical pesticides.

The registration procedure in a sense becomes a device that lulls unsuspecting politicians and citizens into believing that a bureaucratic stamp, labeled "safe", shields them from the dangers of environmental poisoning.

The Weakness of Testing and Development of New Pesticides

The registration of pesticides should be recognized as an integral part of the selection of a chemical as a pesticide. Selection is empirical. No scientific theory exists that enables researchers to predict what chemicals will make good pesticides. Chemical companies select a pesticide through blind screening and test as many as 10,000 compounds to find one marketable pesticide.

The essence of a good pesticide is a chemical that kills or damages the indicated pest, but does not harm non-target species with which it comes in contact. It is this selectivity that must be established and around which the whole registration procedure revolves.

Search for a marketable pesticide occurs in two stages. The first and obvious stage is to find chemicals that kill. Candidate chemicals are tested to find out if they kill insects, weeds or other pests. The initial screening turns up numerous killers which are further tested in refinements of the primary screen to learn their range of targets.

The initial search is relatively easy. Having been selected, candidate chemicals pass into a time-consuming second stage which is expensive and generally indecisive. The second stage asks the question: Is this chemical safe to non-target organisms and what are its long term effects?

The limits to toxicological testing mentioned above have long been recognized. Research on new and more sophisticated testing procedures has proceeded briskly. Although the methodology has a long way to go, especially with respect to the effects of rare amounts of chemicals, it is still much improved over the procedures of ten years ago.

It is customary to subject the candidate pesticide to several tests in a number of organisms. The objective of each test is to prove the chemical unsafe, that is, does it exhibit harmful effects in the test system? The fact that any one procedure shows no evidence of harm does not prove safety, because other tests may show evidence of harm. Essentially, it should take only one test showing harmful effect to fail a candidate.

Thus, the more testing protocols applied to a candidate pesticide and the more sophisticated they become, the less likely the candidate will pass. This situation has an important implication for registration of new pesticides and the review of old ones. What determines a good pesticide is the ratio of its ability to

kill its target versus minimal effects on other organisms. The first part of the ratio, since the advent of the new pesticides 40 years ago, has not changed much. DDT, which ushered in the new era of pest control, has not been surpassed in kill ability and range of targets in spite of several million chemicals being screened.

All chemicals have undesirable side effects. Therefore, as the stringency of safety tightens, the second part of the ratio inexorably moves toward the first part. The so-called selectivity of the pesticide diminishes and consequently its utility diminishes. The selectivity in absolute terms actually does not change; what changes is our knowledge, and that is what counts because informed judgements can only be made on the basis of knowledge.

Pesticide technology could be said to have reached its limit. It is unrealistic to expect that some new miracle chemical pesticide will be discovered that will control pests and not harm non-target organisms in any way. This limitation poses a dilemma. Should registration criteria be maintained at the relatively relaxed level that now prevails or should Canadians insist on more stringent criteria? The presently administered criteria probably represent the limit to what can be applied to candidate pesticides and still allow a few to become registered. The situation is actually even more serious because a whole category of safety evaluation - *environmental safety* - is ignored in current registration decisions.

Role or Lack of Role of Environment Canada

From the environmental point of view, all organisms from soil bacteria and wildlife to humans are non-target organisms. In practice, however, evidence that influences a decision on whether or not to register a pesticide derives from two classes of non-target organisms, humans, and those from which a profit can be made, e.g., crops, fish, cattle, wildlife species having sporting value.

Pesticides represent a class of poisonous chemicals deliberately broadcast into the environment. Environmental processes are so interconnected that damage to any species or to any environmental process could affect every other species. These are questions that environmentalists should be examining in detail. In particular, the federal Department of Environment, with a major commitment to environmental protection, should have a great deal to say about what chemical pesticides will be used and how they will be used. Such is not the case.

Agriculture Canada gained responsibility for pesticide registration long before Environment Canada was created (1971) and before the general public exhibited significant environmental awareness. Consequently, pesticide registration has continued to serve its primary goals of crop and animal production. Environment Canada has failed to reflect public concern over environmental quality and to insist on having a major role in the evaluation of candidate pesticides and the review of existing ones.

This weakness is illustrated in the case of the IBT scandal. The Department took no initiative in assessing the implication to Canadians and the Canadian environment of the some 115 pesticides registered on the basis of the suspect IBT data. It remained for National Health & Welfare to take the initiative, by assigning several senior officials on a full time basis to try to sort out the IBT situation. It was four years after the scandal broke before Environment Canada finally assigned one official to a consultative committee to advise the Minister of Agriculture.

With respect to pesticide impact in general, Environment Canada has been a poor advocate for the environment. An advocate needs knowledge and the Department is poorly organized to obtain that knowledge. Some of the information with respect to environmental impact supplied to Agriculture Canada by pesticide manufacturers for registration purposes is not readily available to the field services of Environment Canada. Through its Forestry and Wildlife Services, the Departmen occasionally does environmental research not knowing what data exist in Agriculture Canada files. Expensive duplication can result.

The research which these Services carry out reflects their specific and limited concerns, but the Department does not undertake more broadly-based research on the impact of pesticides in the Canadian environment. As described on page 14, data to which Environment Canada has access are secured from other countries, often irrelevant to the Canadian context.

Any significant environmental testing of pesticides by Environment Canada is in reaction to decisions by Agriculture Canada, that is, officials respond to problems only after a pesticide is introduced into commerce by instructing its field staff to monitor pesticides when they create a noticeable problem. In dealing with these issues, department officials are hampered by the refusal of Agriculture Canada to release pertinent toxicological data. There have been several cases of Environment Canada field officials being forced to obtain data directly from the manufacturers.

The basis of any systematic monitoring of the environmental impact of pesticides should be precise information on the amounts of each pesticide applied in each locale. The PCP Act does not provide for the gathering of these data. Statistics Canada collects information on the distribution of about five percent of the registered pesticides but their data are not necessarily available to Environment Canada. The important point is that for the remaining 95 percent of registered pesticides, there are no distribution data available to any government officials. The fact that Environment Canada has taken no steps to develop the means to generate such information shows a lack of commitment to effective monitoring of pesticides.

Failure to assess adequately the environmental impact of pesticides goes beyond the simple acquisition of data. Assessment of the environmental impact of pesticides is complex and multi-faceted, involving many skills. Environment Canada has failed to use its available resources skillfully. Internal coordination among its own officials and experts necessary to monitor and effectively research pesticide matters does not exist. This lack of coordination and determination within Environment Canada may explain why the Department plays such a non-assertive role in the registration of pesticides.

We return to the dilemma of the stringency of registration criteria. At present, environmental effects play a small role. Clearly, if Environment Canada were to adopt a more aggressive stance on behalf of the environment, it could choke off registration of most if not all new pesticides.

The answer to the dilemma, if the status quo prevails, could be put crassly: "If you wish to eat, you must accept poisoning". Fortunately, it is not necessary to leave the matter in those terms. There are alternative pest controls developed in Canada which protect production of food and fibre and minimize the risk of poisoning. In view of Environment Canada's mandate to protect and conserve the environment, this Department legitimately should be using its authority and influence to promote these more environmentally compatible alternatives.

III. ALTERNATIVE STRATEGIES TO PEST CONTROL

Chemical pesticides, paradoxically, have taught us much about how ecosystems work. The insect part of the world ecosystem consists of some 1,250,000 species of which only about 10,000 compete with humans, and hence are termed pests. The reason that fewer than one percent are pests is that the insect world consists of a finely balanced ecosystem. Plant feeders, their parasites and insect predators in a natural setting all interact in such a way that no one species ever predominates.

The balance can shift drastically in a monoculture. The widespread growing of a single crop encourages population explosions among pest insects which feed on the crop. A chemical pesticide may bludgeon the insect population into submission but at the same time, because of lack of specificity, it devastates the predator populations. It takes only a few individuals to eventually develop resistant strains. A strain of the European corn rootworm, for example, appeared in Nebraska, the heart of the United States corn belt, and from this small beginning, the resistant pest now infects 18 states (Boraiko, 1980). Such observations demonstrate that crude, heavy-handed overkill by itself does not represent a long term strategy to pest control, and teach us that we must learn much more about ecosystem interaction in general and pest-host biology in particular.

A senior Agriculture Canada official observed that in trying to control insects, authorities have concentrated on the damaging state of a population. He emphasized that control will work effectively only when the population at all stages is studied and appropriate strategies devised (LeRoux, 1969).

The Director, Science and Education, U.S. Department of Agriculture, in a statement that suggests a shift of thinking away from exclusive dependence on chemical-intensive agriculture, observed that "one of the major challenges to agriculture in this decade will be to develop farming systems that can produce the necessary quantity and quality of food and fibre without adversely affecting our soil resources and the environment" (USDA Study Team, 1980). These sentiments have been voiced for years by critics of chemical-intensive farming, but this is the first time a high agricultural official has publically subscribed to them. The key to this view is that although farming comprises a man-made ecosystem, it is in fact very much part of the world natural ecosystem, and it is as subject to its pressures, equilibria and laws as any other part of that system.

In rethinking new approaches to agricultural production, one must accept that insects, weeds and other pests are here to stay. A more effective control strategy is to learn how to co-exist so as to minimize direct competition. Two such strategies, biological control, and a comprehensive management strategy that may include biological control (Integrated Pest Management) are being studied. Although they have yet to become significant parts of mainstream agriculture and forestry, their potential has been successfully demonstrated.

Biological Control

Biological control has been described by the Dean of Graduate School, Simon Fraser University, as the direct or indirect manipulation by man of living natural control agents to increase their attack on pest species (Beirne, 1963). The control must be worked out for each pest. For example, i) A predatory agent or parasite is introduced into the locale that keeps the pest population at a minimum; ii) Cultural practices are changed to enhance an already existing predator or parasite; iii) A specific disease organism of pests is sprayed in the manner of a pesticide giving short term control; iv) Sex attractants (pheromones) can be used to lure insects into traps.

The effectiveness and difficulties of biological control can best be illustrated with case studies.

Cereal Leaf Beetle

This insect (*Oulema melanopus*) attacks the leaves of young grain plants, weakening the plant and thus reducing yield, and for many years was particularly troublesome in the American Midwest. It began to move into Ontario in the early 1970's when, for two seasons, it caused significant economic loss in oat crops. Agriculture Canada officials were concerned that the pest would spread into othe grain growing areas of Canada.

Some years previously, in efforts to cope with the pest, American scientists had imported several potential natural enemies of the leaf beetle from Europe. One of them, a parasitoid, *Tetrastichus julis*, became established. When the beetle migrated into Ontario, the parasitoid migrated with it and fortunately established itself. The parasitoid keeps the beetle population below an economic threshold, i.e., the damage caused is acceptable vis-à-vis the profit on the crop (Harcourt *et al.*, 1977a).

Interestingly,although the cereal beetle is satisfactorily controlled in Canada, it continues to inflict significant damage in the United States. One possible explanation is that the introduced parasitoid finds Canadian climate and cultural practices more similar to conditions in its European home.

Alfalfa Weevil

The Quinte area of Ontario is a prime alfalfa producing area. In the late 1960's, the weevil *Hypera postica* appeared and increased at an alarming rate. A new and particularly destructive pest, the weevil caused multi-million dollar losses reaching their peak in 1974.

Two factors combined to bring the pest under control. Fungi of the *Entomophthora* species appeared in the Quinte area, where this pathogen attacked the larvae and cocoon stages of the pest. In addition, Agriculture Canada and USDA scientists imported a variety of parasites. One of these, *Microtonus aethiopoids*, became established and adapted well to the Quinte area.

For a biological control to be effective, a population of host insects must be maintained at a low level in order that the disease organism or predator can also be maintained at a viable level. The predator thus is always present in case the pest population starts to increase. Ensuring that a sustainable ratio is maintained requires careful monitoring and attention to population dynamics.

The fungi *Entomophthora*, for example, can be too efficient, almost annihilating the weevil population. The pest, of course, is never completely destroyed, the few survivors can stage an explosive comeback, and the parasitic population takes much longer to recover to numbers able to control the weevil. Population oscillations that at times exceed an economic threshhold can occur (Guppy & Harcourt, 1977; Harcourt *et al.*, 1977b). At such times, growers are tempted to spray but this complicates the delicate population interaction. An alternative to spraying is to harvest the alfalfa earlier than normal. Scientists from the Agriculture Canada Ottawa Research Station monitor populations during the growing seasons and can predict 10-14 days in advance when weevil populations will exceed economic levels. In cooperation with the Ontario Ministry of Agriculture & Food, grower-alert information is broadcast on local radio stations. Grower interest and compliance with the advice is high.

Tansy Ragwort

Biological control does not necessarily mean finding a death-dealing predator or foe. It often suffices to weaken the target organism. The biennial weed *tansy ragwort* is particularly noxious on pasture land on Canada's east and west coasts. It is susceptible to defoliation by the *cinnabar moth*, a weed predator introduced

to Canada for the express purpose of controlling the ragwort. Whereas control was successful on the east coast, it was not so on the west coast, where it was found that the longer growing season and mild winter enabled plants to recover from the moth defoliation. The east coast plants, on the other hand, weakened by the moth attack, succumbed to the stress of the more severe winter (Harris *et al.*, 1976).

Codling Moth

Biological controls must be painstakingly worked out for a single pest. If this pest is the dominant one in a crop area, control of it may be all that is needed. Most crops, however, are victims of several pests. The difficulty of management from the growers' point of view can be illustrated by the successful biological control of the *codling moth* in the Okanagan Valley.

The codling moth lays one or two eggs in an incipient apple just after the blossom drops. The egg hatches into a larve which burrows inside and eventually becomes a worm resident in the ripe fruit. A program worked out at the Agriculture Canada Research Station at Summerland in the 1950's made use of sterile male moths.

Male codling moths raised in captivity are subjected to a dose of gamma-rays sufficient to sterilize but not kill them. The males are released in the spring by the tens of millions, the idea being that they would retain their sexual vigour and dilute the population of the natural (fertile) males.

In the mid 1970's, a three-year large scale trial was run in the Similkameen Valley. This area, comprising 1700 acres of apple and pear orchards, was relatively isolated, which is important to prevent re-infestation. The growers as a group agreed to forego their normal chemical spray program. Sterile codling moth males were released over the three seasons and the program reduced fruit damage to an acceptable minimum (Proverbs, 1978).

The program was originally subsidized by the federal Department of Agriculture, in the hope that growers would eventually assume the costs, but the growers looked strictly at the economics. Sterile moth control costs about $250 a hectare and chemical sprays $100. The growers opted for the chemicals, considering that they were spraying for other pests and hence had all the expensive equipment on hand. A full economic analysis that included all environmental effects might have been instructive but no such analysis was done.

Control with Pathogens

Pests, like most forms of life, succumb to a variety of diseases. The objective is to find one that is specific for the indicated pest. The Forest Pest Management Institute at Sault Ste. Marie has identified several pathogens of potential use.

One such pathogen is a nuclear polyhedrosis virus that bears no resemblance to any virus known to infect plants or warm-blooded animals. It is particularly devastating to the *red-headed pine sawfly*. The virus, however, can be propagated only in its host which so far has resisted all attempts at rearing in the laboratory and so the virus is raised in the field where heavy infestations of the sawfly occur. Twenty infected larvae are sufficient to treat one acre at a cost of one dollar, and once introduced, the virus rapidly establishes itself (Cunningham, 1980).

Biological control agents such as this virus must be registered under the PCP Act before they can be used in the field. The Department of Health & Welfare, concerned over a potential human disease hazard, has refused to pass this or any other candidate pathogen, and because of the novelty of registering pathogens, has not offered any protocols that the proponents of the pathogens could follow in establishing safety. It is a curious situation in which shotgun poisons can be registered whereas specific pathogens cannot.

Biological Control in Canada

Agriculture Canada has played an important role in promoting biological control of pests in Canada. From 1948-1955, the Department operated a biological control station at Vancouver for the importation and transfer of potential predators and parasites. The Department also maintained an institute for biological control at Belleville, Ontario, which developed biological control of pests in all parts of Canada. By the 1960's, some 20 insects of importance in agriculture and forest areas, as well as eight weeds, were controlled by introduced predators and parasites (Turnbull & Chant, 1961; Commonwealth Agricultural Bureaux, 1971).

Agriculture Canada policy regarding biological control underwent a significant change in 1955. The Vancouver station was closed, the responsibilities of the Belleville staff were reduced, and pest control was transferred to the regional research stations. For a time, the Belleville institute provided back-up service such as procurement of candidate predators and parasites for basic research until it was closed about ten years later.

The director and some of his senior colleagues joined the faculty of biological sciences at Simon Fraser University, and the other experts scattered to agricultural research stations across Canada. Relocation of these scientists at research stations turned out to have a positive benefit in that their expertise was addressed to specific field problems. Nevertheless, impetus within Agriculture Canada to develop biological controls markedly dropped after 1955 (Commonwealth Agricultural Bureaux, 1971). This dwindling interest, of course, coincided with the arrival of the new synthetic chemical pesticides.

Biological control can be cost effective, but this fact is not generally appreciated because of the lack of adequate economic analysis. The University of California, for example, has maintained a Department of Biological Control for many years. During the period 1923-1959, it completed projects that saved California growers over $115 million, a return of 27 times the $4.3 million invested in the department by the university (Beirne, 1980).

The 1960's might be considered as the nadir of support for and interest in biological control in Canada. Since that time, Agriculture Canada has increased its emphasis on the research and practice of biological control. For example, the budget for the search for foreign predators and parasites that might control Canadian pests rose from $40,000 in 1974 to $250,000 in 1980. This expansion has coincided with the development of an integrated management approach that can amplify appreciably the economic effectiveness of biological control.

Parallel with Agriculture Canada's expansion into biological control, the Canadian Forest Service has stepped up its support. One act was to create in 1977 the Forest Pest Management Institute serving all of Canada, located at Sault Ste. Marie. This institute was formed by the consolidation of the former Insect Pathology Research Institute (Sault Ste. Marie) and the Chemical Control Research Institute (Ottawa). The new institute, with a diversified staff, is better able to investigate biological control of selected pests and to move in the direction of total pest management.

Integrated Pest Management (IPB)

Technical experts have described Integrated Pest Management as "a systems approach to reduce pest damage to tolerable levels through a variety of techniques, including predators and parasites, genetically resistant hosts, natural environmental modifications and, when necessary and appropriate, chemical pesticides" (Report to the President, 1980). This description provides a basic definition, but as will be discussed later, our concept of IPM is substantially enlarged.

Control of the *codling moth* in the apple growing areas of the Niagara Peninsula and Georgian Bay illustrates one technical approach. The time of emergence of the codling moth in the spring depends on temperature, the eggs hatching after a certain amount of warmth. In the late 1960's, scientists at the Agriculture Canada Research Station at Vineland began to determine the exact weather conditions for emergence of moth and hatching of eggs. By plotting heat days, they can predict accurately when the moth will appear and when the eggs will hatch.

Populations of other pests are monitored using sex pheromone traps and visual observations. In collaboration with the extension service of the Ontario Ministry of Agriculture & Food, this information is relayed to growers every spring through a phone-in network. Consequently, growers need spray only once instead of several times. The net result has been a reduction by one-half of the amount of spray used, as well as fewer spray trips through the orchards.

In addition, engineers from the Vineland station have evaluated and designed spray equipment that minimizes unwanted drift, increases efficacy of the spraying operation, and reduces the amount of active ingredient needed to control orchard pests.

About two-thirds of Ontario's apple orchards are covered by this program. Agriculture Canada has established similar programs in Québec, the Annapolis Valley in Nova Scotia and the Okanagan Valley in British Columbia.

Mites vs Mites

Integrated pest management requires that the nature and severity of a pest problem be understood before any action is taken. Control of mites in the Okanagan Valley illustrates this aspect of IPM.

Mites are a major problem in orchards, infecting leaves and reducing yields. Experts at the Agriculture Canada Research Station at Summerland devised a simple device that takes a 10-leaf sample and brushes the mites on to a special plate. Under magnification, mites can be identified and counted, and the information obtained from this sample extrapolated to the entire orchard, from which the field worker can determine if a mite infestation warrants spraying. Moreover, a mite's worst enemy is a predatory mite. The field worker may note, for example, that although the pest mite population is high, the predatory mite population is rapidly building up and if the orchard is left to itself, the pest mite population will soon crash.

IPM in Practice

Any time an agent is applied to the environment, whether biological or chemical, the ecology is disturbed in some way. It has been observed that one no sooner gets one weed under control on rangeland, through establishing a parasite, when another weed starts to take over. Management of pest ecology is far from static. It requires constant adaptation and technical development to match the continual evolution of a living ecosystem.

Perhaps one reason chemical sprays have been so readily accepted in the field is that they require no sophistication or understanding of insect biology on the part of the applicator. Provinces publish spray calendars every spring which provide dates through the season for spraying specified chemicals on each crop. True IPM, in contrast, requires a level of sophistication that few field workers possess.

In Canada, only Simon Fraser University offers a program (graduate) that trains field workers in IPM. In what may be the first service of its type in Canada, two graduates from this program, with the aid of a grant from Agriculture Canada, have set up a pest management business in the Okanagan Valley. For a fee they provide growers with the expertise to minimize pest damage and pesticide costs.

IPM, as currently practiced, begins with an existing production crop to which it tries to fit a pest control program. It is a program that may remain heavily dependent on chemicals although chemical application can be substantially reduced. In many cases it could be made more effective if cultural practices were changed. Intercropping, planting of trap crops and rotation of crops over several seasons can all contribute to pest control. Such practices, however, involve more than science and technology and enter the realm of economics and marketing.

Producers become locked into the marketing of a particular crop. Onion growers in the marshlands of Ontario, for example, must spray chemical pesticides heavily to control annual infestations of an onion root maggot. This maggot apparently could be controlled if growers stopped producing onions for a few seasons, a change in practice the growers are unwilling to make. It is clear that a broader form of IPM will require matching economic and educational policies.

IPM requires Political and Economic Nerve

The difficulty of implementing an IPM program can be illustrated by the story of the *spruce budworm* in New Brunswick, an insect resident in North America long before the arrival of Europeans. It attacks voraciously about every 25 years, almost destroying the forest, which then commences to regenerate. Thus over the long term, the insect/forest relationship can be seen as one of Nature's equilibria.

The human problem arose about 1920 after a saw milling industry had been established. The spruce budworm outbreak of that period caused severe economic loss. By the time of the next cyclic outbreak (about 1950), six pulp and paper mills had been established in the province. Clearly, neither politically nor economically could the insect's destructive capability be tolerated.

New Brunswick, in 1952, began a program of aerial spraying of large sections of the province. Evidence based on control areas was that in 1952 (a year of heavy infestations), spraying held population levels at about 20 percent of the expected peak. The problem was that with annual spraying, which has continued to the present time, the budworm population, rather than pulsing, has remained at an intermediate, partially destructive level. The spraying operation could hardly be called a management program. It did offer, however, crop protection that allowed the forest industry to expand. It also offered time to develop a rational plan of management that unfortunately remained largely unused.

A Task Force on the budworm, chaired by the Director of Graduate Studies, Faculty of Forestry, University of New Brunswick, listed 11 alternative control strategies based on biological control[6], three based on chemical-biological combinations and one based on cultural practices (Baskerville, 1976). The difficulty, according to the report, is that these alternatives remain at the research stage. The relatively large sums of money and the political nerve necessary to bring any one or a combination of methods to an operational scale have so far been absent. There is no incentive to the industrial sector to invest the necessary sums to develop alternatives. Parenthetically, there is no incentive to develop pesticides specifically against the spruce budworm. Those chemicals used were developed for other purposes and just happen to exhibit effectiveness against the budworm.

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[6]An example of biological control in the use of the infectious (to insects) bacteria *Bacillus thuringiensis*. This organism has been extensively tested under field conditions by the Canadian Forestry Service under the direction of W.A. Smirnoff (Smirnoff, 1978, 1979).

It is a case of a region being on a pesticide treadmill, a rather unsatisfactory one at that, afraid and unwilling to undertake measures that might rescue it. It is a case of a province holding a large chunk of its economic well-being ransom to one or two chemical pesticides. When they fail, or become unavailable[7], can replacements be found, or what will result if public pressure results in sudden cancellation of the spray program?

IPM Without Pesticides

IPM does not always have to be carried out over a large region. It can work for selected types of operations, for example, at the unit farm level. One group of practical farmers, through a combination of techniques, has almost dispensed with chemical pesticides. Concerned with a steady decline in soil productivity and quality, with excessive erosion and loss of organic matter, and with chemical hazards to humans and animals, they have shifted away from chemical-intensive farming to what can be termed ecological or organic farming.

These farmers, numbering some 20,000 in the United States (no tally is available for Canada), quietly undertook their revolution over the past several decades, completely ignored by the official agricultural establishment. That disdain, at least in the United States, ended in July 1980 when the Secretary of Agriculture published the results of an extensive study of organic farming conducted by officials of USDA (USDA Study Team, 1980).

The organic farmers surveyed varied in their use of chemical pesticides from absolutely no use to occasional use. The survey found that these farmers, all above average in skill and sense of purpose, successfully controlled weeds and insects by cultural practices of timely cultivation, planting, rotation and the use of trap crops in commercial operations competing with chemical-intensive neighbours. Yields were not necessarily better than those of their chemical neighbours, but with lower input costs, net incomes were as high or higher. Rather than returning to the practices of the 1920's and 1930's, these farmers used certified seeds, the latest equipment, and farm management. They organized existing agriculture knowledge with their own efforts and intuition creatively and effectively.

The USDA Study Team was sufficiently impressed by this demonstration of success in the field that it recommended that

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[7]There is nothing to prevent a company, for reasons of its own, from withdrawing its (patented) product. Canada's pesticides are at the mercy of boardroom decisions in other countries.

USDA develop research and educational programs "to address the needs and problems of organic farmers and to enhance the success of conventional (chemical-intensive) farmers who may want to shift toward organic farming, adopt some organic methods, or reduce their dependency upon agricultural chemicals."

The organic farming approach may not work on all soils or under all climatic conditions, but it is important to realize that those farmers practicing this form of agriculture have received little support from government or universities compared to that which chemical-intensive farms receive. They have been forced to develop their techniques on their own. The lack of official interest in Canada is underlined by the lack of surveys or scientific studies of the potential effectiveness of organic farms under Canadian conditions.

The organic or non-chemical farming movement has demonstrated that it is a viable alternative. It warrants significant support from the agricultural research and educational establishment, support which does not exist at present.

Alternative Strategies, An Enlarged Perspective

Integrated Pest Management programs, including use of biological controls, are technical programs designed to solve specific technical problems. For the most part, they are superimposed on existing agriculture and forestry practices, whether or not these practices are necessary or in the best interest of the people and the environment. The concept of IPM needs to be enlarged to include economic and social considerations.

To illustrate: much of Canada's agriculture is based on single crops, different ones for different regions. Single crop economics results in a substantial infrastructure to service the operation and to market the product. IPM, in many cases, would work much better if crops were rotated, mixed, etc., but from the producer's point of view this is impossible because they have become locked into a particular single crop. Thus, an effective IPM strategy will have to examine the whole situation and, where necessary, provide appropriate economic incentives to encourage producers to modify their cultural practices.

The secret of successful IPM is to work with the natural rhythms of nature. Although many of these rhythms apply to living processes in general, the subtle ones with which IPM must harmonize are peculiar to a locale or region. Agriculture Canada, the Canadian Forestry Service and other institutions have demonstrated the technical effectiveness of alternative techniques. To take full advantage of such techniques requires integration of relevant economic and social values into the overall harmony.

IV. OPTIONS FOR PEST CONTROL IN CANADA

Restatement of Problem

The bureaucratic mechanisms for regulation of candidate pesticides look impressive when viewed on paper. Under the primary authority of the federal Pest Control Products Act, Agriculture Canada has established a regulatory bureaucracy with advisory links to several other federal departments. Each province has enacted supplementary legislation that tightens control. In addition, numerous interdepartmental and national advisory committees advise on aspects of pest control. In spite of all these bureaucratic mechanisms, however, environmental concerns have fallen through the cracks.

Environmental impact of pesticides is poorly assessed and monitored for two reasons. Firstly, the federal government in general, and Environment Canada in particular, poorly manages its available expertise, and more important, has not allocated sufficient resources necessary to monitor and assess pesticide impact.

The second reason is the lack of fundamental understanding of the environmental effects of toxic chemicals, of which pesticides represents a class. Much more basic research needs to be undertaken. The federal government has failed to exercise vigorous leadership in facilitating the development of fundamental knowledge, either through in-house research or through extra-mural grants.

The lack of knowledge of the environmental impact of pesticides is not peculiar to Canada. An EPA review of pesticide hazard assessment in the United States stated, "a significant amount of the nearly 1.5 billion pounds of pesticides which are introduced into the U.S. environment annually is contributed by pesticides whose inherent toxicity and other properties are not well-understood, despite half a century of Federal pesticide regulation." (Wayland, 1979).

Although details are lacking, sufficient scientific evidence has accumulated to demonstrate that pesticides impact significantly on the environment. In effect, Canadians are being forced to accept a degree of risk from pesticides that no one can quantify or precisely define. That risk stems directly from exposure to pesticide residues and indirectly from any deterioration in environmental quality caused by pesticide use. The public is becoming increasingly less tolerant towards the imposition of such unknown risks, a fact that policy makers must take into account.

In terms of pest control, chemical technology has peaked and appears to be in a decline as pests develop resistance to existing pesticides and few new pesticides emerge from industrial research laboratories.

Chemical pesticides represent only one means to control pests. There are alternatives, but because chemical pesticides over the past 40 years have dominated agricultural and forestry policy, alternatives have not received the attention they deserve. Clearly, events have overtaken a pest-control strategy embodied in the 1930's Pest Control Products Act. There is urgent need for development of new strategies broadly based on environmental realities.

At the government level, an environmental perspective is expressed mainly by Departments of the Environment. The charge of the federal Minister's advisory council is to Environment Canada. Accordingly, this report concludes that the Department should give serious consideration to the following four options.

Option One: Change Nothing

According to some officials, the present safety assessment and review of pesticides works well enough. Agriculture Canada makes the final decisions concerning the ultimate interpretations, compromises and trade-offs, with respect to demonstrated benefits and perceived risks. This department is production-oriented and it is hard to imagine a bias towards the agricultural benefits of pesticides not entering into its judgements. Indeed, Agriculture Canada has taken the position that there must be hard incontrovertible proof of serious harm before it will consider seriously such data in its risk assessment.

For reasons mentioned in the body of this report, Environment Canada generates practically no information about environmental impact, hard or soft. Thus it makes no significant input into the risk side of Agriculture Canada's risk/benefit judgements (see Appendix 2 for more details). Nevertheless, by virtue of its administrative role in the pesticide regulatory process, Environment Canada does have a public responsibility. If it chooses not to exercise that responsibility, it should make public its reasons.

Every year the weight of toxic pesticides applied to the Canadian environment exceeds the sum total of toxicants buried in the Love Canal in New York State. Environment Canada finds itself in the vulnerable position of failing to set in motion mechanisms to assess the environmental effects of that burden. It is unable to claim that there are no serious toxic effects because it simply does not know.

The Department could be embarrassed by its inconsistency in taking a strong stand on acid rain and toxic wastes, but failing to control the environmental effects of pesticides over which it has some jurisdiction.

In the forestry sector, the Department, by relying on decreasingly effective chemical pesticides, risks jeopardizing tens of billions of dollars of income, tens of thousands of jobs and incurring charges of ineptitude.

Option Two: Tighten up Environment Canada's Role in Pesticide Registration

The Department could take action in two sectors. First, in the assessment of candidate new chemicals for registration, it could demand that tests be conducted under Canadian environmental conditions, in particular studies on persistence, pathways of movement through the Canadian biosphere and effects on selected Canadian species. These studies should be backed up by fundamental studies into significant indicator species, the development of suitable test protocols and identification of the kinds of potential environmental damage.

Second, in the monitoring of environmental effects of pesticides once registered and used, Environment Canada must know the exact geographical distribution and timing of use of each pesticide. It would need a field staff of experts for such monitoring, who must be supported by basic research mentioned above.

These two actions would represent a substantial commitment of manpower and resources. There are other hurdles. Pesticide companies have made it clear that for most of their products, the Canadian market does not warrant extensive testing in the Canadian environment. They state that if forced to pay for such testing, they may withdraw their products. The cost is borne by the public whether in price of pesticides or in taxes. Should it be left up to international chemical companies to set policy whether or not pesticides are tested under Canadian conditions?

With respect to distribution data, the chemical companies have that information but refuse to release it. Changes in the law will be necessary to gain access to such data. It is unlikely that pesticide producers will yield the data without a strong political battle.

More important than these hurdles is the implication to the whole registration process if Environment Canada takes a strong stance. In order to be registered, a candidate pesticide must already satisfy a long list of safety protocols. Last year, only four new pesticides were registered in Canada after running that gauntlet, which contained few environmentally significant protocols. If environmental safety protocols were added to the list, it is doubtful that very many, if any, candidate pesticides would pass. Moreover, if the 405 currently registered pesticides were subjected to proper environmental studies, most would likely have to be withdrawn.

In brief, most pesticides in Canada arrived on the market today because Environment Canada did not do its job. If it did its job properly, the resulting confrontation with the agriculture and forestry sectors could be time-consuming and politically ruinous. On the other hand, the Canadian public may soon be asking the Department to exercise its mandate and to protect the environment.

Option Three: Authority for the PCP Transferred to the Minister of the Environment

Transfer of the PCP Act to the authority of the Minister of Environment would remove the obvious bias that now exists in Agriculture Canada and would change the focus of assessment from crop production to an environmental one. There is ample precedence in several jurisdictions for putting pesticide registration under the aegis of an environmental authority.

In the United States, the Environmental Protection Agency has full authority over registration of new pesticides and review of existing ones. This authority is exercised in consultation with agriculture and human health agencies.

In Canada, seven of the ten provinces assign their pesticide legislation to the jurisdiction of their ministries of environment. In Ontario, for example, a Pesticides Advisory Committee reviews all aspects of pesticide registration in the province. This committee can recommend banning the sale and/or use of a pesticide even though the federal government approves it. The committee advises the Ontario Minister of Environment, who has the authority to follow the recommendation.

If responsibility for administration of the PCP Act were transferred to the federal Minister of Environment, it would be expected that the present consultation with National Health & Welfare, Fisheries & Oceans, and Agriculture Canada could continue. The bureaucracy

for registering pesticides now located within Agriculture Canada would be transferred to the jurisdiction of Environment Canada. The presence of the Canadian Forestry Service within Environment Canada might be considered as creating a conflict of interest, but few pesticides are actually used in the forestry service so that for the vast majority of pesticides, no conflict of interest would result. Moreover, the PCP Act would be administered most likely by the Environmental Protection Service, a agency in its own right within Environment Canada.

Environment Canada is currently developing means for the overall management of toxic chemicals. Responsibility for registration of pesticides would give the Department control over this significant class of environmental poisons within its broader toxic chemical mandate.

Nevertheless, although transfer of authority for pesticide registration to Environment Canada would remove some of the biases currently present, given the practicalities of pesticide use, it is not certain that there would be any significant change in the amount and kind of pesticides currently registered. Though there might be some improvement in environmental scrutiny of new pesticides, the problems with pesticide technology identified in this report cannot be solved simply by bureaucratic reorganization.

Option Four: Comprehensive Evaluation of Pest Control Strategies by a Commission

Pest control has been considered mainly as a technological problem. Satisfactory control, however, can be achieved only through a melding of technological means with economic and social policy. Pest control cannot be achieved, therefore, by a regulatory system that stresses a single technical facet of control, chemical pesticides. What is needed is an evaluation mechanism that examines complete strategies, a mechanism that is not adversarial, but creative.

In designing such an evaluation mechanism, five constituencies should be satisfied.

1. The *agricultural and forestry sectors* are responsible for the economic wellbeing of a large proportion of the Canadian population. It is these sectors that face the reality of pest competition. Implementation of new control strategies must recognize the legitimate interests of those sectors, enhancing their productive and social worth.

2. *People and their environment* must be protected. The economic value of the agricultural and forestry sectors will cease to be important if the public is poisoned or environmental quality deteriorates.

3. *Government bureaucracies* are obliged to administer regulatory systems. Public servants can become frustrated when given unrealistic programs to administer and/or inadequate resources.

4. *Private enterprise*, whether chemical companies or developers and purveyors of alternative controls, should be encouraged. New pest management techniques will require new types of management companies and there will be an urgent need for a new generation of specific pest control products suitable for Canada, all of which can be undertaken by the private sector.

5. *Politicians* must answer to an increasingly sophisticated public, a public increasingly articulate with respect to its rights and concerns. Politicians should not be put into indefensible positions by outmoded and inappropriate pest control policies.

To reconcile these and other concerns and responsibilities, the fourth option consists of a comprehensive evaluation system. Instead of simply passing judgement on a chemical pesticide, comprehensive evaluation turns the situation around. It examines the pest problem and asks: how can this problem be solved? What means are available? It may be a biological control, or a selective pesticide. It may take the form of a sophisticated IPM approach. It may mean stopping production of a particular crop for a few seasons, while compensating the producers appropriately.

Comprehensive evaluation scrutinizes economic, social and technical implications within an overall goal of preserving and enhancing the quality of the natural environment. It is a creative process. It encourages research and field trials, and would have the broad authority to seek out the economically and technologically most advantageous control strategy.

It is beyond the scope of this report to detail the exact workings of such a comprehensive evaluation procedure, but it suggests in outline a governmental means for achieving it.

A comprehensive evaluation mechanism must have the power to integrate broadly based technology and economic policies. The federal government in other sectors has created such an agency, for example, the special "one stop" textile and clothing agency. This agency has the authority and funding to integrate and focus all government interests towards the restructuring of Canada's textile and clothing industries.

Comprehensive evaluation of pest control strategies, however, would be best administered by an independent *Pest Control Evaluation Commission* with its own statutory authority to make and implement decisions. Precedence for this kind of an agency exists in, for example, the National Energy Board. In reflecting the broad scope of the pest control problem, appointments to the Commission would be shared by the Ministers of Agriculture, Environment, and National Health & Welfare. Statutory authority, however, is absolutely essential. The problems of rationalizing a technical system of food and fibre production within ecological constraints imposed by nature are so complex that only a Commission with broad authority could function effectively.

The independence of a Pest Control Evaluation Commission in placing its decisions at arms length from the ministers would be to their advantage as it would remove criticism of bias. Ministers, however, would exercise influence indirectly, because credibility of the Commission would rest squarely on cooperation with the operating departments and their scientific and managerial expertise.

The purpose of the Commission would be to focus research studies and regulatory action, not on a single means (chemical pesticides) to deal with pest control, but on the problem itself and *all* the alternatives available for its resolution. Its function would be to review the problems, integrate the economic policies and promote support of the technologies required to prosecute the strategy it chooses.

The Commission would need its own staff organization, some individuals being initially seconded from the relevant agencies. Responsibility for research, development and implementation of strategies would remain with the operational departments.

Agriculture Canada and the Canadian Forestry Service should receive increased support for devising and putting into practice comprehensive control strategies. Effective implementation would require close cooperation with provincial authorities and their facilities. These authorities are fully aware of the need to improve control methods and of the potential dangers of using chemical pesticides. The fact that seven of the ten provinces have assigned pesticide regulation to their Departments of Environment attest to their concern.

In addition, it is anticipated that an emphasis on the more ecological strategies would stimulate increased research at Canadian universities, where there will undoubtedly be a need for many new graduates trained to work on the development of total control procedures.

The information on which the Commission would base its decisions and the reasons for them should be open to the public.

The recommended Pest Control Evaluation Commission would represent a long term approach. During the transition period as the Commission develops its competence and programs, chemical pesticides will still need to be regulated. The Commission would take over authority for the PCP Act or its successor. Although one objective of the new approach would be to minimize the environmental impact of chemical pesticides, it is envisaged that they would continue to be used for the foreseeable future.

What are the advantages of the comprehensive approach?

1. Pest control strategies would be implemented that are designed in Canada for Canadian conditions.

2. Opportunities for research and development would be increased. Research does not pay off until it finds practical application. The fourth option provides a vehicle for more rapid implementation of research findings in the field of genetic engineering, plant science, insect biology, microprocessors and many other pertinent fields.

3. New jobs would be created. In effect, pest control technology would move from other countries to Canada.

4. It would result in increased, environmentally compatible production in the forestry and agriculture sectors. The comprehensive

evaluation approach sets as a goal stewardship of the environment. By encouraging environmentally acceptable programs, the stage is set for increased production without degradation.

5. The quality of the environment and human life would be enhanced by substantially lessening the environmental impact of chemical pesticides.

Environment Canada's Role in the Fourth Option

The adoption by the Department of either option 2 or option 3 would represent a significant increase over its present activity in the pesticide field. To consider either, however, is to look backwards to the 1930's PCP Act.

The Department is undertaking a major initiative in coming to grips with the toxic chemicals problem. The Minister has announced, as a major objective for the 1980's, the implementation of a Toxic Chemicals Management Program that will effectively reduce the toxic burden on the Canadian environment. Consistent with that objective, the Department could better exercise its responsibilities towards pest control and the environment through a comprehensive evaluation mechanism. It is recommended that the Department take a major leadership role in the creation of a Pest Control Evaluation Commission, the work of which would mesh with the broad intent of the Toxic Chemicals Management Program. Environment Canada would be the one agency with a grasp of the total toxic chemical position, and would be able to feed this vital information to the Commission.

The work and success of the Commission would depend heavily on Environment Canada support in the following areas:

1. Research into the establishment of effective evaluation protocols for environmental impact.

2. Monitoring of pesticide use in Canada (see comments under option 2).

3. Research and development of management procedures that integrate knowledge of pesticide burdens with total toxic burdens of the Canadian environment.

4. Maintenance of effective liaison with international bodies concerned with similar issues.

5. In the forestry sector, research and implementation of forest pest management programs.

6. In the wildlife sector, research on fundamental understanding of species interactions and use of selected species as biological indicators to toxic chemical impact.

7. As the presumptive steward for quality of the Canadian environment, the Department would cooperate with the agriculture sector to help ensure that Canada's farm lands remain productive and viable.

Conclusion

Chemical pesticides, although they control effectively many pests, impose an environmental and human health burden. Because that burden cannot be adequately assessed, the present risk/benefit judgements made in order to register a pesticide are invalid. Imposition of unknown risks could be avoided or minimized by implementing alternative control strategies. A regulatory system focussed on chemical pesticide registration does not encourage such implementation. The time has come to shift emphasis to facilitating total control strategies.

The Canadian Environmental Advisory Council favours the creation of an independent Commission as a means to undertaking a new approach to pest control.

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APPENDIX 1

PESTICIDES IDENTIFIED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY AND THE HEALTH PROTECTION BRANCH, CANADA NATIONAL HEALTH & WELFARE AS BEING SUPPORTED BY ONE OR MORE STUDIES PERFORMED BY THE INDUSTRIAL BIOTEST LABORATORIES INC.

Acephate
Alachlor
Alanap
Alar
Allidochlor
Ametryn
Antor
Atrazine
Azodrin
B. Thuringiensis
Barban
Bifenox
Binapacryl
Bromofenoxim
Bux
Captan
Captafol
Carbofuran
Chlorbromuron
Chlorpropham
Chlorpyrifos
Chlorathalonil
Ciodrin
Cyanazine
Cyprazine
Dacthal
Delnav
Desmedipham
Dialifor
Diallate
Diazion
Dibrom
Dichlobenil
Difenzoquat
Dinitramine
Dinoseb
Diquat
Disulfoton
Dyanap
Edifenphos
Embar
Endosulfan
Endothall
Ethiolate
Ethion
Fenamiphos
Fenitrothion
Fensulfothion
Fentin Hydroxide
Fenvalerate
Folpet
Formetante hydrochloride
Glyphosate
Glyphosine
Harvade
Metobromuron
Methamidophos
Methidathion
Methiocarb
Methoprene
Metolachlor
Metribuzin
Norea
Nicotine Sulphate
Omite
Oxydemeton methyl
Paraquat
Penncap E
Penncap M
Permethrin
Phenmedipham
Phosphamidon
Picloram
Polyram
Profenofos
Propham
Profluralin
Propachlor
Propoxur
Prowl
Pyrethrins
Simazine
Sumithrin
TCMTB
Terbufos
Terbuthylazine
Terbutryn
Tedion
Tetrachlorvinphos
Thiofanox
Toxaphene
Triallate
Trivax
Vapona
Vegadex
Vendex
Vitavax

Data supplied by the Department of National Health & Welfare

APPENDIX 2

ROLE OF ENVIRONMENT CANADA IN THE PESTICIDE REGISTRATION PROCESS

The role of Environment Canada is that of advisor to Agriculture Canada. Environment Canada has no legal authority to back up decisions pertaining to the acceptability of a pesticide from the environmental viewpoint. Final decisions rest with Agriculture Canada.

The initial application for registration is submitted to the Plant Products Directorate of Agriculture Canada. The administrator decides, in collaboration with departmental advisors, which parts of the application are relevant to the Canadian Forestry Service, Canadian Wildlife Service or Environmental Protection Service of Environment Canada. The total applications are voluminous and Environment Canada officials, in defence of their time, prefer to concentrate on what, in their opinion, are the relevant sections.

The Canadian Forestry Service, for example, reviews only those chemicals that are intended to be used in forestry - a relatively small number. Thus, although in effect it has a responsibility for a large part of the Canadian environment (that covered by by forests), it has no opportunity or for that matter the resources to evaluate comprehensively all pesticides.

The Environmental Protection Service provides one individual to review pesticide applications in the total context of environmental impact. The Service has no list of specific tests it uses as criteria for judgement. It does, however, make use of protocols suggested by the U.S. Environmental Protection Agency. This information includes data on persistence, mobility and toxicity to two fish species (one cold water, one warm water), and two birds species such as quail and mallard. One or two mammals may also be included. These data are developed for U.S. conditions, although Environment Canada may require at times additional information about persistence and mobility in Canadian regions where the pesticide will be used.

The Department provides no research backup for the review process undertaken by this one official of the Environmental Protection Service. The Canadian Forestry Service, on the other hand, does have a research capability, but its review is limited to very few chemicals. The Department, moreover, has no committment to the repeated review of already registered pesticides.

Overall, environmental input into the pesticide registration process is haphazard and cursory. It is a small component of decisions centered on crop protection.

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